10/523254
DT05 Rec'd PCT/PTO 26 JAN 2005
[10191/3720]

METHOD FOR CONTROLLING AND/OR REGULATING A D.C. CONVERTER FOR AT LEAST TWO ELECTROMAGNETIC VALVES OF AN INTERNAL COMBUSTION ENGINE, IN PARTICULAR IN A MOTOR VEHICLE

Field Of The Invention

The present invention is directed to a method for controlling and/or regulating a d.c. converter for at least two electromagnetic valves of an internal combustion engine in which each valve is supplied with a current generated by the d.c. converter. The present invention also relates to a corresponding device for controlling and/or regulating a d.c. converter for at least two electromagnetic valves.

Background Information

It is known that a plurality of electromagnetic valves may be supplied with current by a d.c. converter via an output stage. In this context, it is possible for overlapping currents for the different valves to result in a high load for the d.c. converter as a whole. The d.c. converter must be designed for this high load, which is associated with increased expenditure under some circumstances.

Summary Of The Invention

The object of the present invention is to provide a method in which the expenditure for processing a high load of the d.c. converter is reduced.

This object is achieved with the method according to the present invention by determining when the total currents supplied to the valves represent a high load for the d.c. converter, and if this is the case, by adapting the d.c. converter for improved processing of the high load. The present invention also provides a corresponding device.

EU 331376302 US

The d.c. converter is set to the high load using the present invention. Thus, the d.c. converter is capable of better processing this high load. This in turn entails the advantage that the d.c. converter need no longer be designed on the basis of the high load but instead may be designed by taking into account the better processing according to the present invention. In particular, it is possible to select the output capacitor of the d.c. converter to be smaller than would be necessary to match a high load.

In an advantageous further refinement of the present invention, the output voltage of the d.c. converter is increased when there is a high load. The output voltage may be controlled and/or regulated to a setpoint value and the setpoint value may be increased.

This measure achieves the result that the high load of the d.c. converter results in a lower dip in the output voltage. In particular, as already mentioned, the smaller dip in the output voltage allows a smaller output capacitor of the d.c. converter to be used.

It is particularly advantageous if the increase in the output voltage and/or the setpoint value is already performed before the high load occurs. Thus the d.c. converter is prepared for the high load. In this case, the output voltage already increases to the full extent when the high load occurs and is thus effective.

A further implementation of the present invention includes a computer program having program commands suitable for execution of the method according to the present invention when the computer program runs on a computer. Accordingly, the present invention is implemented by a digital storage medium including a computer program having program commands suitable for executing the method according to the present invention.

Brief Description Of The Drawings

Figure 1 shows a schematic block diagram of an exemplary embodiment of a device according to the present invention for controlling at least two electromagnetic valves of an internal combustion engine.

Figure 2 shows a schematic wiring diagram for one of the electromagnetic valves with the current flow in four successive time ranges.

Figure 3 shows a schematic time chart of the current across one of the electromagnetic valves in the four time ranges.

Figures 4a-4c show three schematic time charts of currents and voltages across, or at, the electromagnetic valves.

Detailed Description

Figure 1 shows a device 10 for controlling at least two electromagnetic valves 11, 12. Electromagnetic valves 11, 12 are provided for use in an internal combustion engine in a motor vehicle in particular. For example, electromagnetic valves 11, 12 may be provided in conjunction with an electrohydraulic valve control for the intake and exhaust valves of the internal combustion engine. In this case, a hydraulic system is controlled via electromagnetic valves 11, 12, the intake and exhaust valves of the internal combustion engine being able to be opened and closed using the hydraulic system.

It is pointed out here explicitly that device 10 may be used not only for two valves 11, 12 depicted here, but may also be used for any number of valves through appropriate expansions. It is thus possible to have a total of 32 solenoid valves for controlling the intake and exhaust valves of the internal combustion engine in the case of an engine having four cylinders.

Two d.c. converters 13, 14, which together form a converter 17, are provided for supplying power to valves 11, 12. Both d.c. converters 13, 14 and thus converter 17 include control means and/or regulating means for maintaining the generated output voltages at a predetermined setpoint level.

D.c. converter 13 is suitable for generating a booster current on an electric line 15. Accordingly, d.c. converter 14 is suitable for generating a holding current on an electric line 16. The booster current is greater than the holding current.

An output stage 20, which controls the current flow across valves 11, 12, is provided between d.c. converters 13, 14 and valves 11, 12. This control takes place via a control unit 19. The function of output stage 20, its control, and the generated current flow across valve 11 is explained in greater detail below in connection with Figure 2. The explanation given there also applies accordingly to the current flow across valve 12 and the current flow across any additional valve.

Figure 2 shows lines 15, 16 coming from two d.c. converters 13, 14. Line 16 is connected via a diode D1, which is connected in the flow direction, to one of the two terminals of electromagnetic valve 11. The other terminal of electromagnetic valve 11 is connected via a diode D2, which is also connected in the flow direction, to line 15. The cathodes of both diodes D1, D2 are interconnected via a switch S1. The anode of diode D2 is connected to ground via a switch S2.

Depending on the switch positions of two switches S1, S2, there is a different current flow across valve 11. Four different switch positions resulting in four different current flows in four successive time ranges a, b, c, d may be set using two switches S1, S2. Control unit 19 as already mentioned controls the positions of two switches S1, S2.

Figure 3 shows current I_{MV} across electromagnetic valve 11 as a function of time. In particular, Figure 3 shows four time ranges a, b, c, d resulting from the four adjustable switch positions of two switches S1, S2.

In first time range a, both switches S1, S2 are closed. This yields current flow a, as shown in Figure 2 and designated accordingly as "a." The booster current generated by d.c. converter 13 flows across valve 11. This current I_{MV} increases to a final value according to Figure 3 and is provided to adjust valve 11 into a preselected end position in any case.

In second time range b, which follows time range a, switch S1 is closed and switch S2 is opened. This yields a current flow as shown in Figure 2 and designated accordingly as "b." This current flow is known as free-running. This means that at least a portion of the electric energy contained in electromagnetic valve 11 is dissipated via this free-running state. Accordingly, current I_{MV} declines in time range b according to Figure 3.

Switch S1 is opened in time range c and switch S2 is closed. This yields a current flow like that shown in Figure 2, where it is designated accordingly as "c." The holding current generated by d.c. converter 14 in time range c is sent to valve 11. This holding current is selected so that the end position reached by valve 11 on the basis of the booster current does not change.

Both switches S1, S2 are opened in time range d, which follows time range c. This yields a current flow like that shown in Figure 2 and designated accordingly as "d." This current flow represents quenching of electromagnetic valve 11. This means that the energy in electromagnetic valve 11 is dissipated

completely to 0. Current I_{MV} then issuing from valve 11 flows across diode D2 to d.c. converter 13 in time range d.

Figure 4a shows booster current I_B for connected valves 11, 12 generated by d.c. converter 13, plotted as a function of time t.

On the basis of two or more valves 11, 12 present here, it is possible for the booster currents of time ranges a of two or even more valves 11, 12 to overlap. Such overlap together with the resulting high booster current is designated by reference numeral 22 in Figure 4a.

High booster current 22 results in d.c. converter 13 being exposed to very high loads. The following is provided for better processing of these loads:

Control unit 19 is connected to converter 17 via line 18, in particular to d.c. converter 13, which is responsible for the booster current. Control unit 19 determines when a high load has occurred due to overlapping booster currents. Control unit 19 is able to derive this from the provided triggerings of switches S1, S2 of output stage 20.

Before a high load occurs, control unit 19 indicates the imminent high load to converter 17, in particular d.c. converter 13. This is accomplished with the help of a signal S, which is sent from control unit 19 via line 18 to converter 17.

Figure 4b shows signal S plotted as a function of time t. It is apparent here that signal S is present during a period of time T, which extends from a point in time T1 to a point in time T2. This is designated by reference numeral 23 in Figure 4b. Period of time T corresponds approximately to the period of time during which high booster current 22 from Figure 4 is present.

Figure 4c shows output voltage U_B of d.c. converter 13 plotted as a function of time. As mentioned previously, this output voltage U_B is controlled and/or regulated to a predetermined setpoint value. The setpoint value is designated as $U_{Bsetpoint}$ in Figure 4c. Control and/or regulation of d.c. converter 13 is designed, for example, so that output voltage U_B of d.c. converter 13 varies in a tolerance range of ±10% around setpoint value U_{BS}.

As Figure 4c shows, setpoint value U_{BS} of output voltage U_B of d.c. converter 13 is raised during period of time T. This is indicated with a dashed line in Figure 4c and labeled as 24.

As already mentioned, period of time T of Figure 4b begins shortly before the rise in high booster current 22 in Figure 4a after time T1. As a result, setpoint value $U_{Bsetpoint}$ also increases just prior to the rise in high booster current 22. This increase in setpoint value $U_{Bsetpoint}$ also yields an increase in output voltage U_B of d.c. converter 13, which is shown by a dashed line in Figure 4c and is designated by reference numeral 25.

After the point in time when booster current I_B (which is designated as 22 in Figure 4a) rises, d.c. converter 13 thus supplies an increased output voltage U_B (designated as 25). This yields the result that d.c. converter 13 is able to better process the high load associated with the rise in booster current I_B.

In particular, increased setpoint value $U_{Bsetpoint}$ and resulting increased output voltage U_B result in the dip in this output voltage U_B due to high booster current I_B being lower than would be the case without the aforementioned increase. This is shown in Figure 4c on the basis of the curves designated by reference numerals 26, 27. The curve resulting from the increase in setpoint value $U_{Bsetpoint}$ is indicated by a dashed

line and is designated by reference numeral 26, while the curve that would result without the above-described increase in setpoint value $U_{Bsetpoint}$ is designated by reference numeral 27.

Due to the smaller dip in output voltage U_B (designated as 26 in Figure 4c), it is possible to provide d.c. converter 13 with a lower output capacitance than would be necessary without the increase in setpoint value $U_{Bsetpoint}$. It is likewise possible for the control and/or regulating means contained in converter 17 to take preventive measures on the basis of signal S, namely in particular on the basis of the rise in signal S at the beginning of period of time T and to do so as a preventive measure even before the occurrence of a system deviation to counteract the system deviation that would result on the basis of the high booster current. In particular, the control and/or regulating means may increase the output power of d.c. converter 13 as a preventive measure.

Other emergency functions may be implemented via line 18 as follows:

For example, if d.c. converter 14 fails and if this is detected by control unit 19 via measures not described more closely in the present case, control unit 19 may control and/or regulate remaining d.c. converter 13 so that it assumes the function of d.c. converter 14 and additionally generates the holding current. For example, the output voltage of d.c. converter 13 may be pulsed to thereby generate a corresponding holding current.

In the inverse case, control unit 19 may control and/or regulate d.c. converter 14 so that it generates not only the holding current but also the booster current. In particular, control unit 19 may increase the setpoint value of the output voltage of d.c. converter 14. In addition, it may be advisable for control unit 19 to trigger switches S1, S2 at an earlier

point in time for generating the booster current to thus compensate for possible deterioration of the tightening dynamics of valves 11, 12.